MANUFACTURE OF SOFT MAGNETIC PARTS
FROM COARSE IRON POWDER

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The magnetic properties of ferromagnetic materials are strongly affected by such factors as plastic deformation and heat treatment. The complex mechanism involved in the comminution and displacement of crystal grains during the plastic deformation of a ferromagnetic is responsible for changes in the latter's domain structure, which in turn bring about changes in many of the physical (mechanical, electrical, and magnetic) properties of the material.

The present work was undertaken with the aim of determining under what deformation and annealing conditions the maximum attainable magnetic properties can be imparted to specimens produced from iron powder. It is well known that the effect of grain size on the magnetic properties of pure iron is greater than that of impurity inclusions, because lattice distortions at grain boundaries influence these properties more strongly than do impurities. By choosing a suitable combination of deformation reduction and crystallization annealing temperature, it is possible to ensure that a structural grain of the required size will be produced.

In this work, PZh1K and PZh2K powders* were selected for investigation (Table 1). Specimens were prepared by pressing the powders under a pressure of 6 tons/cm² and sintering the resultant compacts for 30 min at 760°C. The

*Coarse-reduced iron powders – Translator.

Fig. 1. Structure of iron powder specimen after sintering at 1160°C, × 300.

Fig. 2. Structures of specimens after deformation with reduction of 3.2 (a) and 4.2-4.6% (b), followed by annealing at 860°C, × 300.
specimens were then re-pressed and annealed for 4 h at 1160°C. Next, they were subjected to compression in a die with a reduction of 3.3% and also to free compression with a reduction of 42-46%. The final annealing of the compressed specimens was performed for 3 h at 860°C.

The magnetic characteristics of the specimens are listed in Table 2. From the data obtained it follows that the production technique employed enables a high induction and a coercive force of about 2 Oe to be obtained in iron powder specimens. The magnetic properties investigated are structure-sensitive, and it was therefore necessary to discover how the structure of the material changed in the course of specimen preparation.

After double pressing and sintering at 1160°C, the specimens had a density of 6.9-7.0 g/cm³ and a structure as shown in Fig. 1. Lattice distortions induced by subsequent working had a deleterious effect on their magnetic properties: the maximum magnetic permeability decreased by 25-30% and the coercive force increased by 15-20%. Additional annealing for 3 h at 860°C produced grain growth (Fig. 2) and relieved elastic stresses in the material. As a result of this, the maximum magnetic permeability rose to 2600 G/Oe in the case of die-compressed specimens and 3600 G/Oe in the case of specimens subjected to free compression. The coercive force appreciably fell after free compression (from 2.3 to 1.8 Oe) and, at the same time, specimens were found to have a larger grain (Fig. 3). The induction sharply rose (to 16,500-17,000 G) after free compression with a reduction of 46%. The improvement in properties was promoted also by an increase in density, to 7.5-7.6 g/cm³.